HiResClim

Making EC-Earth3 a high-resolution climate forecast system

F.J. Doblas-Reyes
ICREA and IC3, Barcelona, Spain

M. Asif, L.-P. Caron, C. Prodhomme (IC3),
L. Batté (Météo-France)

SPECS
Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

iCrea IC3

HiResClim

High-resolution climate modelling and prediction with EC-Earth3 and CNRM-CM (EC-Earth with IC3, KNMI and SMHI, CERFACS).

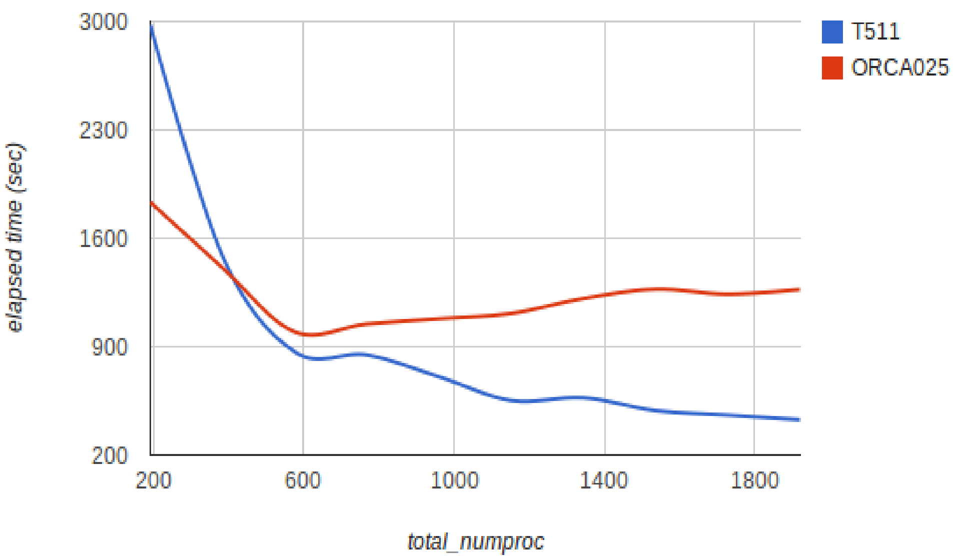
PRACE provided 38 + 50 Mhours on Marenostrum3 in two phases. Running phase ending in December 2014.

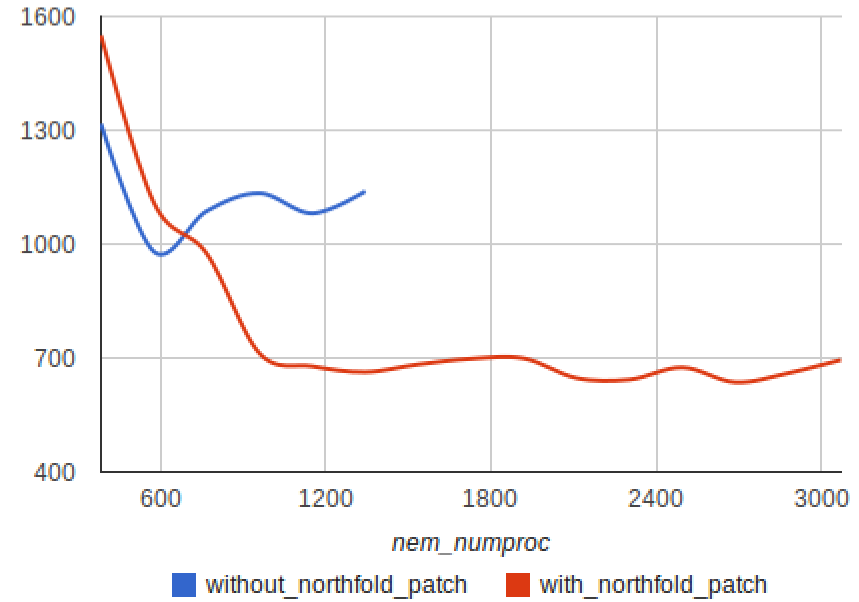
Planned: Spin up (control) + historical simulations + projections + decadal (17 start dates, 10 members, 10 forecast years) + seasonal (34 start dates, 10 members, 7 forecast months), several thousand years, several hundreds of TB.

EC-Earth with v3.1 at T511/ORCA025 resolution.

Scaling EC-Earth3 HR

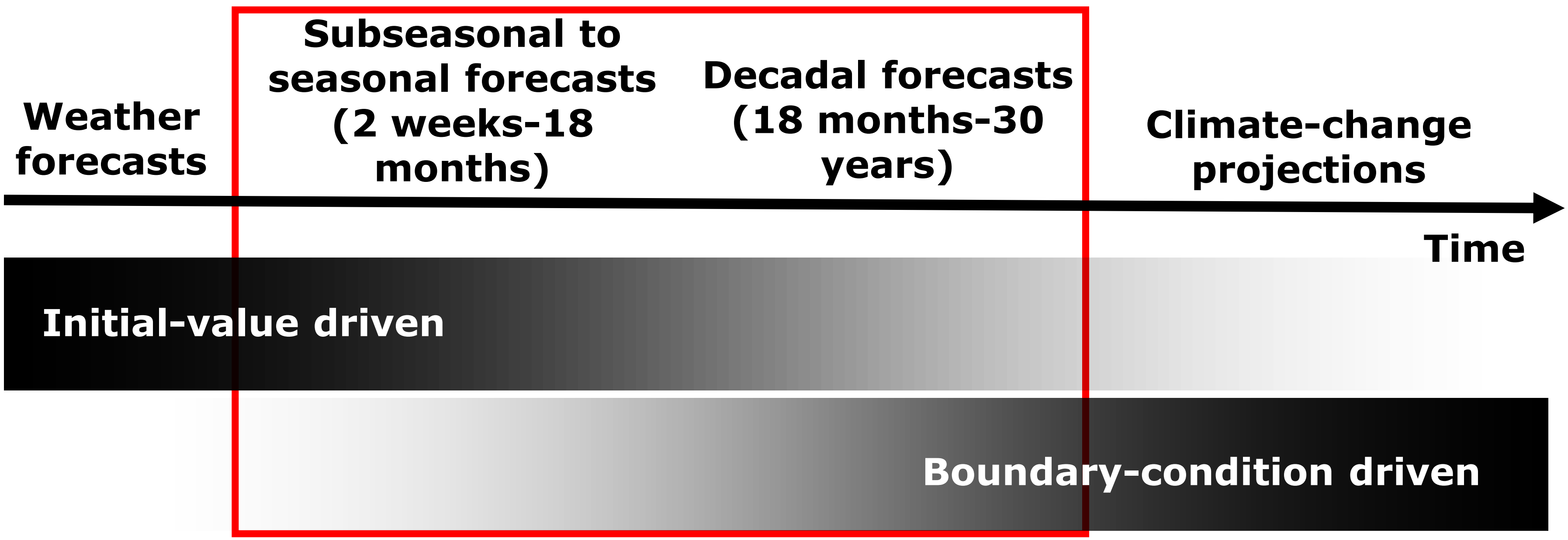
(Left) Scaling of IFS (Cy36R4) T511L91 and NEMO3.3 ORCA025L75, with LIM3 on Marenostrum3: elapsed time for 10-day simulations with standard output. NEMO saturates at around 600 cores. (Right) Scaling of EC-Earth3 T511L91/ORCA025L75 as a function of the cores used for IFS. Several options for the number of NEMO cores are considered. **NEMO is the limiting factor in EC-Earth3 HR and reaches its efficiency limit at 600 cores (around 900 with optimization).**





Climate prediction

Progression from initial-value problems with weather forecasting at one end and multi-decadal to century projections as a forced boundary condition problem at the other, with climate prediction (sub-seasonal, seasonal and decadal) in the middle. Prediction involves initialization and systematic comparison with a simultaneous reference.



Adapted from Meehl et al. (2009)

Climate predictions

Climate prediction allows running jobs independently by wrapping together ensemble members for different start dates. This is not trivial parallelisation.

EC-Earth3 at Lindgren, PDC						
Number of Start Dates		1	5	10	10	20
Number of Members		1	5	5	10	10
Number of Independent Simulations		1	25	50	100	200
T159-ORCA1	Cores	144	3600	7200	14400	28800
	Wall-clock Time (Hours) / year	5	5	5	5	5
	CPU Time (Hours) / year	720	18000	36000	72000	144000
	Output Size (GB) / year	10,80	480	960	1920	3840
T255-ORCA1	Cores	360	9000	18000	36000	72000
	Wall-clock Time (Hours) / year	5	5	5	5	5
	CPU Time (Hours) / year	1800	45000	90000	180000	360000
	Output Size (GB) / year	19,20	5184	10368	20736	41472
T799-ORCA025	Cores	1104	27600	55200	110400	220800
	Wall-clock Time (Hours) / year	40	40	40	40	40
	CPU Time (Hours) / year	44160	1104000	2208000	4416000	8832000
	Output Size (GB) / year	256,80	6420	12840	25680	51360

SPECS motivation

What: to produce quasi-operational and actionable local climate information

Why: need information with improved forecast quality, a focus on extreme climate events and enhanced communication and services for RCOFs, NHMSs and a wide range of public and private stakeholders

How: with a new generation of reliable European climate forecast systems, including initialised ESMs, efficient regionalisation tools and combination methods, and an enhanced dissemination and communication protocol

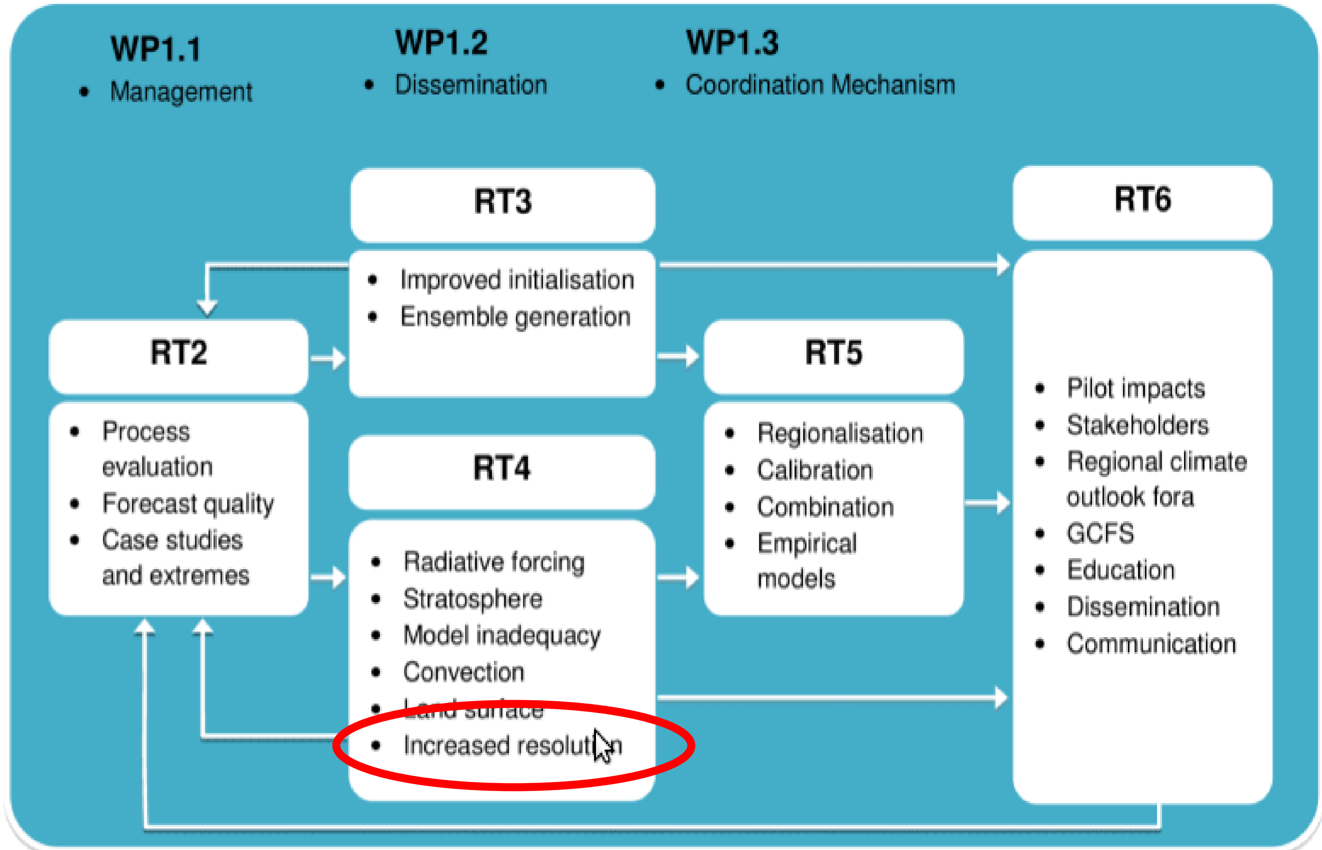
Where: over land, focus on Europe, Africa, South America

When: seasonal-to-decadal time scales over the longest possible observational period

http://www.specs-fp7.eu

SPECS: Overall strategy

Forecast System	Project Partners
CNRM-CM5	CNRM, CERFACS
EC-Earth	KNMI, SMHI, IC3, ENEA
IFS/NEMO	ECMWF, UOXF
IPSL-CM5	CNRS
MPI-ESM	MPG, UniHH
UM	UKMET

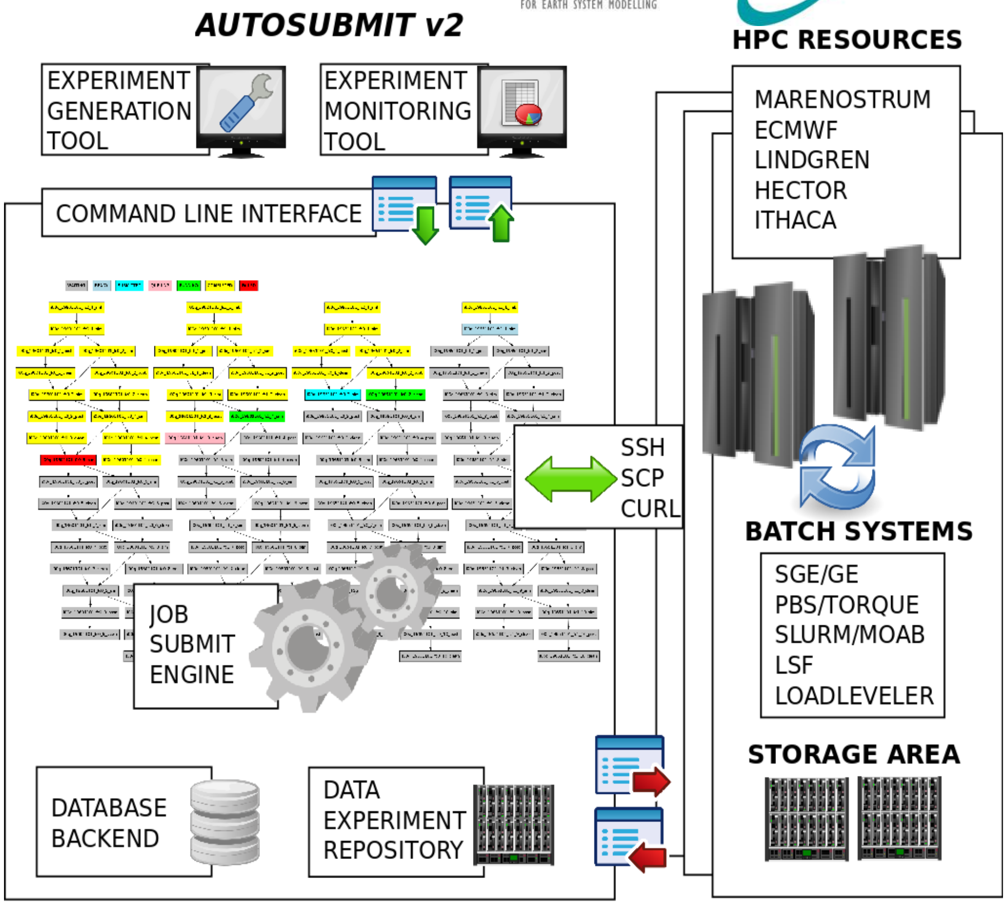


WP1.1: Management
WP1.2: Dissemination
WP1.3: Coordination across EUPORIAS, NACLIM & SPECS
RT2: Evaluation of current s2d forecast systems
RT3: Forecast strategies
RT4: Improved systems
RT5: Calibrated predictions at the local scale

Autosubmit

Autosubmit acts as a wrapper to run a climate experiment on any HPC. The experiment is a sequence of jobs that it submits, manages and monitors. When a job is complete, the next one can be executed.

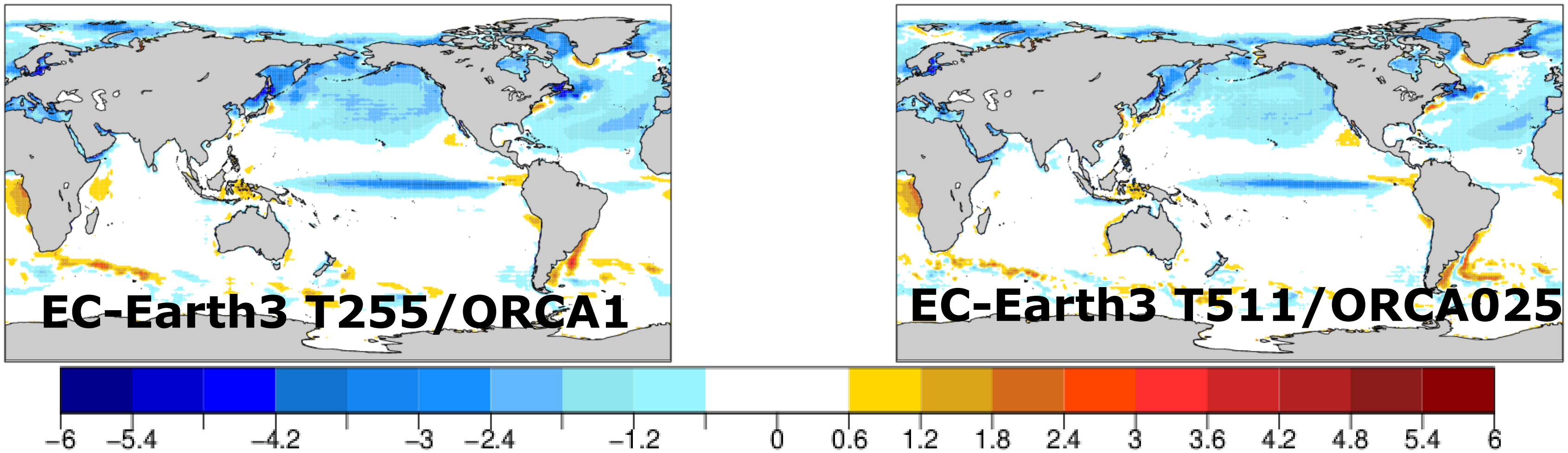
- Divided in 3 phases: ExpID assign, experiment creation (including access to GIT repository), run.
- Separation experiment/autosubmit codes.
- Config files for autosubmit/experiment.
- Database to store information.
- Common templates for all platforms.
- Recovery after crashes.
- Dealing with a list of schedulers and communication protocols.
- Moving to Cylc in the next few months.

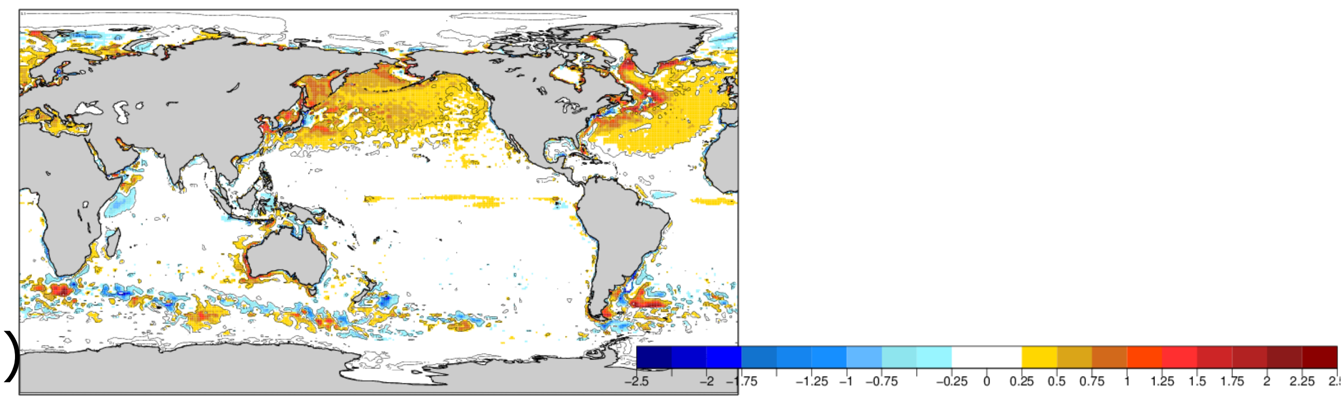


One colour per status in the monitoring tool: yellow=completed, green=running, blue=pending, etc.

Changes in mean climate

Mean SST (K) systematic error versus ERAInt for JJA one-month lead predictions of EC-Earth3 T255/ORCA1 and T511/ORCA025. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions.

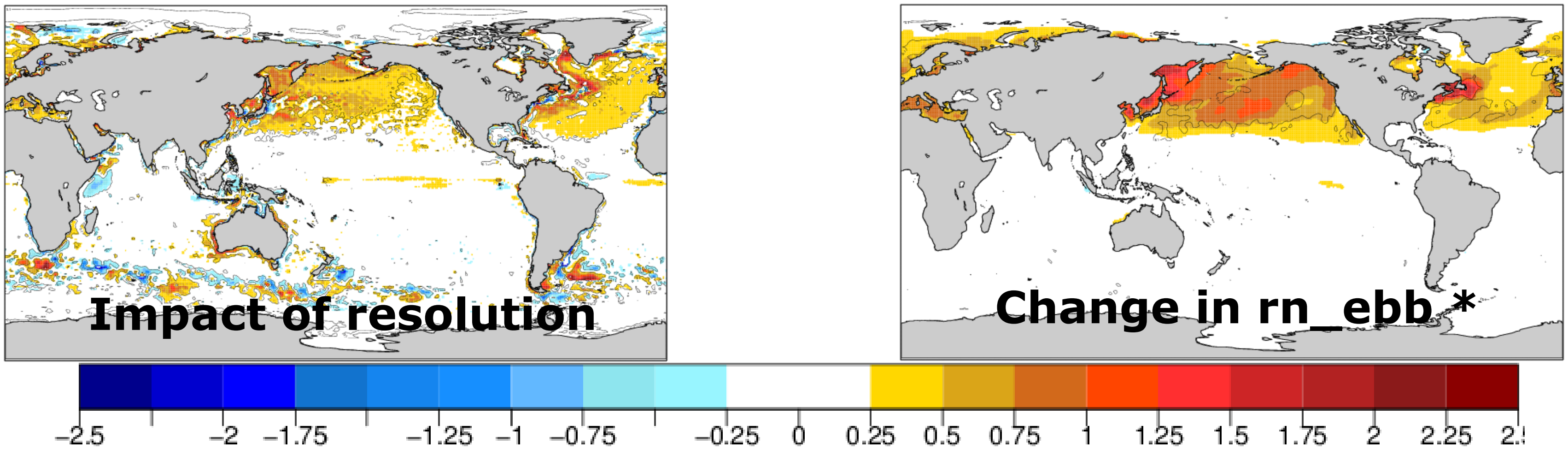




C. Prodhomme (IC3)

Changes in mean climate

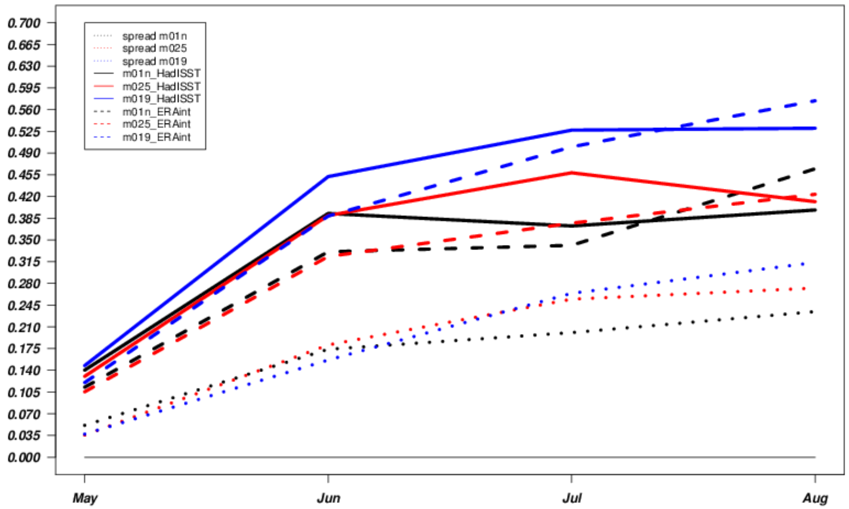
Mean difference of SST (K) systematic error versus ERAInt for JJA one-month lead predictions with EC-Earth3. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions.



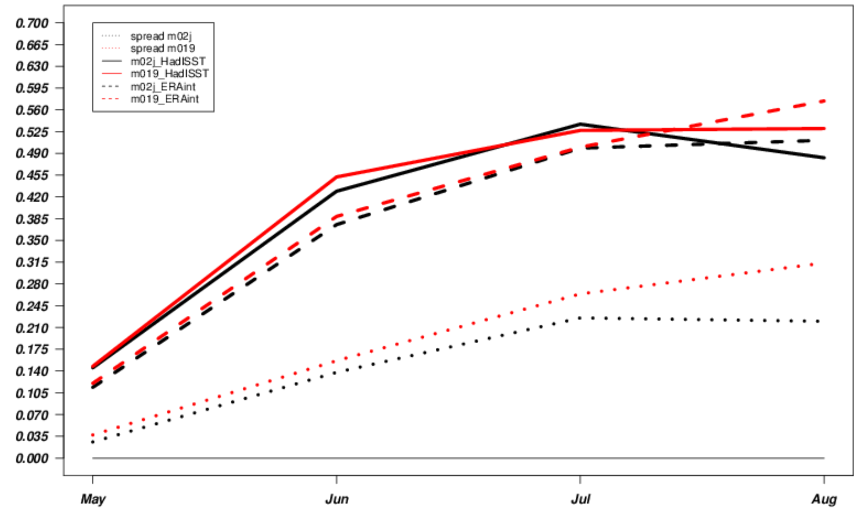
* rn_ebb: coef. of the surface input of tke

Forecast quality

RMSE (solid and dashed) and spread (dotted) of Niño3.4 SST from four-month EC-Earth3 hindcasts: (left) T255/ORCA1, T511/ORCA025 and T255/ORCA025; (right) official release and modified rn_ebb. May start dates over 1993-2009 using ERA-Interim and GLORYS initial conditions.



Impact of resolution



Change in rn_ebb

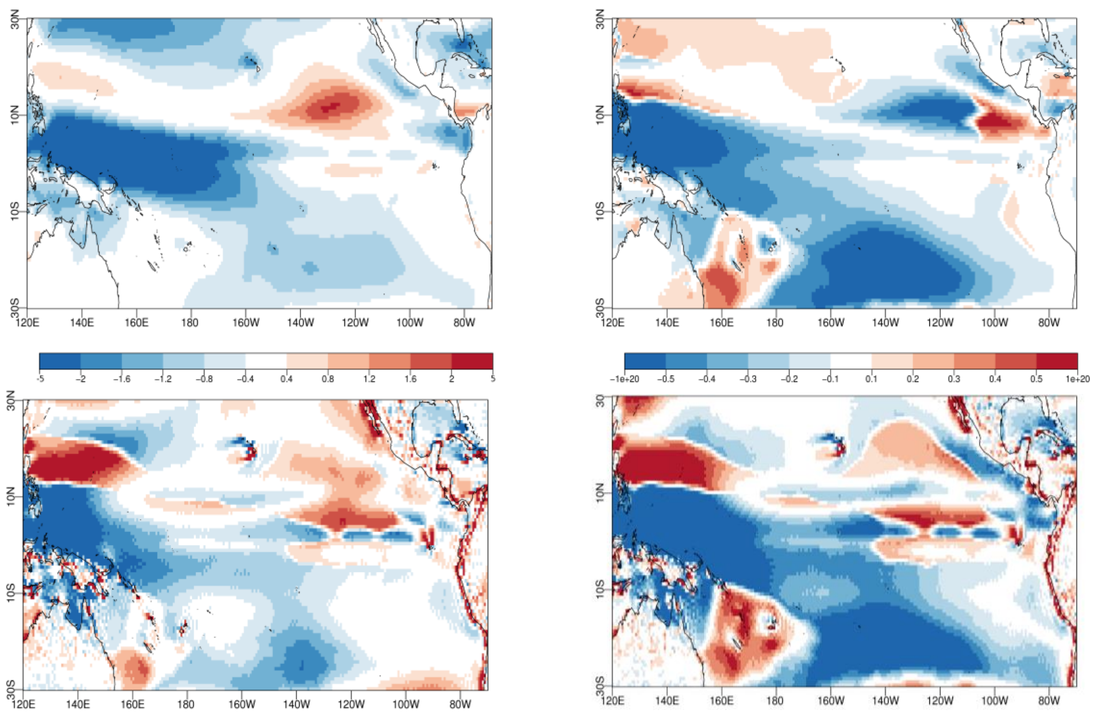
C. Prodhomme (IC3)

Stochastic physics

10-metre zonal wind JJA systematic error (versus ERAInt) and error reduction from EC-Earth3 simulations: standard resolution (**SR**, **T255/ORCA1**), high resolution (**HR**, **T511/ORCA025**) without and with stochastic physics (**SPPT3**). May start dates over 1993-2009 using ERA-Interim and GLORYS and ten-member ensembles.

SR systematic error

SR SPPT3 error reduction



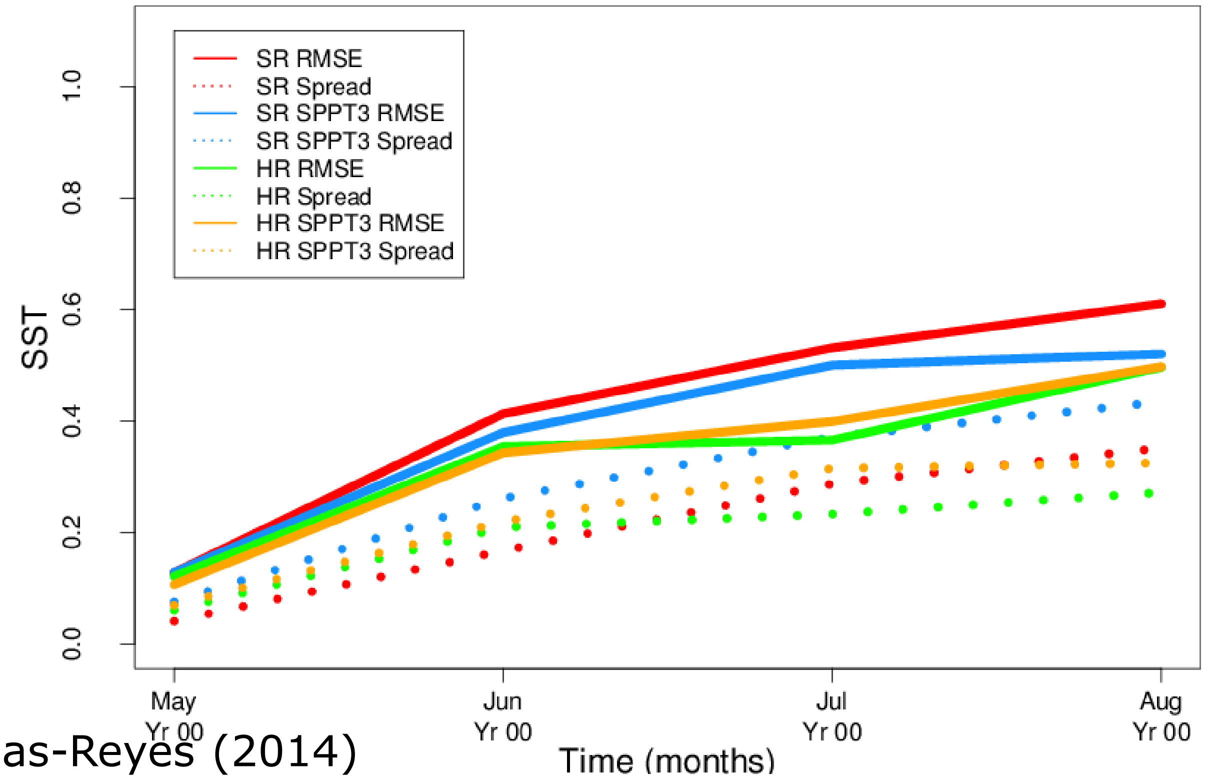
HR systematic error

HR SPPT3 error reduction

Batté and Doblas-Reyes (2014)

Forecast quality

RMSE and spread of Niño3.4 SST (versus ERSST) from EC-Earth3 simulations: standard resolution (**SR**, **T255/ORCA1**), high resolution (**HR**, **T511/ORCA025**) without and with stochastic physics (**SPPT3**). May start dates over 1993-2009 using ERA-Interim and GLORYS and ten-member ensembles.

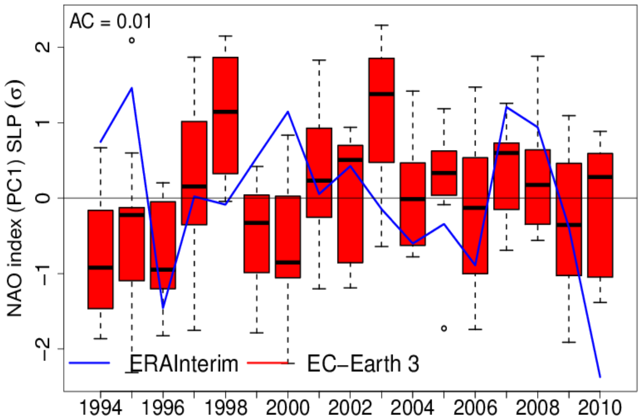


Batté and Doblas-Reyes (2014)

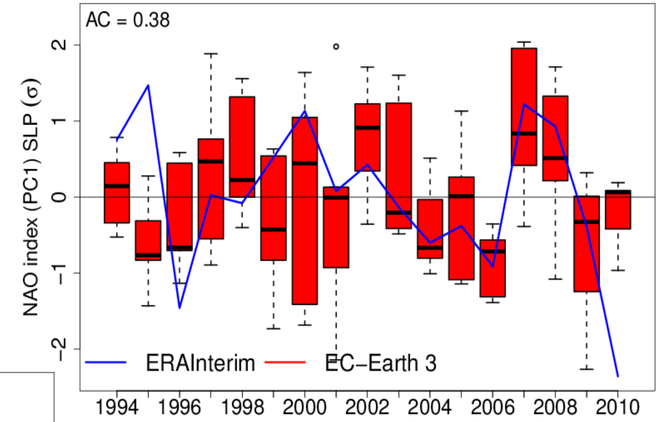
Extra-tropical circulation

Predictions of DJF NAO with EC-Earth3 **SR and HR** and ECMWF S4 started in November over 1993-2009 with ERA-Interim and GLORYS initial conditions and five-member ensembles. Correlation of the ensemble mean on top left.

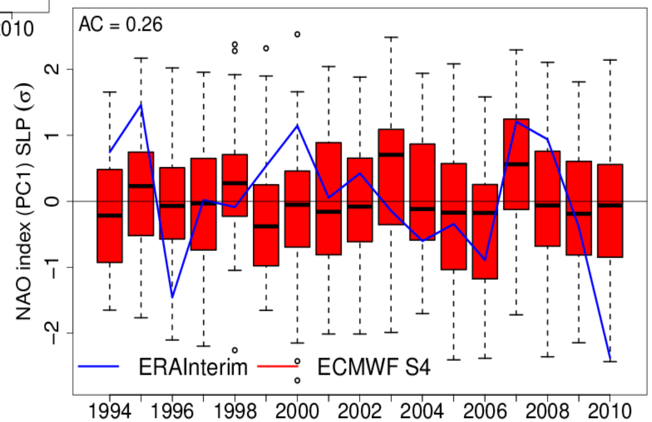
EC-Earth3 T255/ORCA1



EC-Earth3 T511/ORCA025



ECMWF S4



Batté et al. (2014)

Decadal prediction

Real-time decadal prediction exchange. Figures now available, predictions distributed soon.

http://www.metoffice.gov.uk/research/climate/seasonal-to-decadal/long-range/decadal-multimodel

Multi-model decadal forecast exchange

The Met Office coordinates an informal exchange of near-real time decadal predictions. Many institutions around the world are developing decadal prediction capability and this informal exchange is intended to facilitate research and collaboration on the topic.

The contributing prediction systems are a mixture of dynamical and statistical methods. The prediction from each institute is shown below, alongside an average of all the models. When possible, observations for the period of the forecast are also shown. Currently three variables are included: surface air temperature, sea-level pressure and precipitation. These are shown as differences from the 1971-2000 baseline. More diagnostics, including ocean variables are planned for the future. Please use the drop-down menus below to explore the data collected to date.

This work is supported by the European Commission SPECS project.

SPECS

Seasonal-to-decadal climate Prediction for the improvement of European Climate Services

To learn more about decadal forecasts at the Met Office, see our current decadal forecast.

Images last updated 2014-02-20

Issued	Period	Element
2012	year 1	surface air temperature

Decadal forecast exchange 2012 predictions for year 1 surface air temperature

Some comments

- <u>Climate-prediction scientists work on</u>
  - initialisation
  - model improvement
  - calibration and combination to provide climate information
  - evaluation and forecast quality assessment
  - improving processes: sea ice, aerosols, vegetation and land, …
- <u>Challenges to assess the impact of resolution</u>
  - efficient and adapted workflows
  - applications easily portable to the platforms where the computing time is allocated (the present for "computing of opportunity" is multi-platform, heterogeneous architectures)
  - data reduction, ways to handle the increasing data volume, data analytics where the data reside
  - need more embedded computing scientists